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Statement of
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Associate Administrator
Office of Aerospace Technology
before the
Subcommittee on Space and Aeronautics
Committee on Science
House of Representatives

Mr. Chairman and Members of the Subcommittee:

Thank you for this opportunity to share with you a few of the many technical and business accomplishments that NASA's Space Launch Initiative (SLI) has delivered in its inaugural year.

The United States has more than 40 years of experience in space and is the only country with reusable launch vehicle (RLV) capabilities. The Nation has enjoyed the benefits of scientific discovery that new forms of transportation have historically made possible. In practical terms, space transportation enables not only the robust civil exploration of space, but also the critical capacity to defend National assets, while it fosters economic and technological growth across many commercial sectors — from communications to navigation, from weather forecasting to global environmental research.

NASA's Space Launch Initiative (SLI) began in February 2001, with the first Nationwide contracts awarded in May 2001. It recently underwent a comprehensive evaluation through the Interim Architecture and Technology Review (IATR) process, and realigned its organization for accountability and innovation. This report gives specific business and technical accomplishments, as well as outlines the SLI business plan and puts it into a greater strategic context.

Background on the NASA Integrated Space Transportation Plan

NASA's strategic goals for a next generation space transportation vehicle are to significantly reduce the risk of crew loss, reduce ground processing times in addition to other lifecycle cost drivers, and thus reduce the overall costs of access to space. The plan for achieving these goals is the Integrated Space Transportation Plan (ISTP). NASA currently spends nearly one-third of its budget on space transportation; the ISTP is NASA's strategy for reducing these costs and thereby making these funds available for NASA's core science research, technology development, and exploration activities. Plans are currently underway for an Agency update to the ISTP where NASA will revisit our current and future technology investment decisions.

ISTP is the governing framework that coordinates and guides NASA's various space transportation investments, including Space Shuttle improvements, SLI, and far-term technology. ISTP is the decision path by which NASA ensures continued access to the International Space Station, invests to reduce its human space flight transportation costs, and avoids duplicative or unnecessary human space flight transportation investments. ISTP consists of three major components:

1. Space Shuttle Improvements – Improvements to the safety of the Space Shuttle through ground and flight system upgrades, and facilities revitalization;

2. Space Launch Initiative – Risk reduction and development of a lower cost, safer, privately operated space transportation capability to replace the Space Shuttle early next decade; and

3. Far-Term Technology – Investments in far-term space transportation technology to maintain a technology base for future vehicles.

ISTP calls for a decision at mid-decade (2006), depending on progress in SLI risk reduction, on whether to undertake full-scale development of a new human space flight transportation system available by early next decade (planned initial operational capability by 2012).

Space Launch Initiative Overview

The SLI program is an integral part of NASA's strategy to help refocus the Agency's resources on core scientific research by reducing the operations budget that NASA spends annually on space transportation. The SLI program is working with the U.S. aerospace industry to design a privately operated 2nd Generation RLV that will reduce "loss of crew" and mission risks and is more cost-effective compared to today's Space Shuttle. By reducing costs, improving reliable access to space, and allowing NASA to focus its workforce on its core missions, SLI will impact scientific and technological goals that are critical to improving U.S. leadership in space exploration. The SLI program is not only reducing the technical risks involved in developing new launch vehicles, but also reinventing the basic program-project management processes and procedures for fielding a new space transportation system. The Space Launch Initiative is reducing the risks inherent in an advanced research and development program of this magnitude, while fostering a fair business environment for industry and ensuring the wise use of valuable resources. Through teamwork with its partners in the U.S. aerospace industry, academia, and the military complex, NASA contributes its experience in space transportation systems research and development to enable a new generation of space transportation capabilities for a stronger America.

The fundamental work funded by the SLI program is the initial stage required to reduce risk and formulate plans with a high confidence of success for the full-scale development and flight stages to follow. Activities now underway across NASA and the country will result in two competing space transportation system architectures — complete to the Preliminary Design Review — supported by a portfolio of advanced, high-payoff technologies such as long-life rocket engines, robust thermal protection materials, sophisticated diagnostic software, and crew-related enhancements. SLI encompasses a two-fold approach: conceptually *designing* complete space transportation systems that can fulfill basic civil and commercial mission requirements, while reducing the risk of building and operating the system finally chosen for full-scale development around mid-decade.

To ensure success, NASA has brought together some of the Nation's most talented scientists and engineers, while making available its extensive research, test, development, and evaluation facilities, some of which are one-of-a-kind. Comprehensive top-to-bottom systems engineering and the cost-control process ensure that the Government gets what it pays for by measuring technical progress at regular intervals. A central SLI tenet is that the research funded must be directly relevant to SLI goals to reduce the risk of developing a safer, more reliable, and less expensive space transportation system that will enable NASA to pursue its ultimate strategic goals. The Program's acquisition strategy allows it the flexibility to add new tasks to fill technology gaps and spur competition, or to rescope and descope efforts.

SLI is much more than just another hardware program; it embodies the expansion of business, scientific, and technological capabilities for a new century of privately operated, efficient and cost-effective space access, and a transition that will see NASA as a buyer of services rather than as an operator of infrastructure.

This Agency-wide and, indeed, Nationwide initiative was founded on studies jointly conducted with industry in the late 1990s. From the beginning, SLI was planned to meet fundamental National science and technology research priorities using systems that are privately operated and compatible with commercial payloads. Launch market research and technology readiness continues to influence the direction taken by SLI.

A Year of Business and Technical Success

The SLI program plan is designed to "buy down" technical and business risk, and puts NASA in a position in 2006 to have high confidence in the success and cost of a new system, with the detailed blueprints for both a reusable launch vehicle and its complete operational infrastructure. An important part of this deliverable will be detailed cost estimates, including defined uncertainties, for building and operating the system, and a procurement opportunity to move into the next stage of developing this new National capability.

The SLI Team approaches the business of building a complete space transportation system with clearly defined phases that have major reviews as milestones. The top-level plan is patterned after the highly successful Apollo and Shuttle programs. Table 1 shows how, in the bigger scheme, SLI encompasses the initial two-part Formulation Phase (preliminary concepts, requirements definition). When realistic blueprints are laid for the Implementation Phase to follow, during which the system enters a detailed design phase, then is built, operated, and eventually retired.

In its inaugural year, the Space Launch Initiative has delivered numerous technical and business accomplishments, a few which are discussed below. After the recent Interim Architecture and Technology Review, architectures were focused from hundreds of concepts to 15 of the most promising candidates to go forward into more detailed development. As technology trade studies are focused and validated through a rigorous systems engineering process, the two will merge again in the Systems Requirements Review milestone in FY 2003. This further narrows the field to one design from each of three prime contractors, and defines which technologies require further investment to enable the eventual winner to be built and become operational.

As the SLI Program progresses from FY 2003 through FY 2006, at least two competing space transportation system architectures will be developed to the Preliminary Design Review stage, ready for a full-scale development decision around mid-decade. These designs, which will support basic Government and commercial mission requirements, will be backed up by a portfolio of advanced technologies such as long-life rocket engines, robust thermal protection materials, sophisticated diagnostic software, and features that will enable crews much greater safety and protection. In this way, America will have a new capability to explore the Earth and beyond sometime early in the next decade that can eventually replace the capabilities now provided by the Space Shuttle.

TABLE 1. SLI Program technical review milestones.

Phase	Activity	Key Technical Reviews
1. Formulation (SLI) FY01-03	Conceptual Design & Analysis	• Interim Architecture & Technology Review • Systems Requirements Review
2. Formulation (SLI) FY03-06	Preliminary Design & Analysis	• Systems Design Review • Preliminary Design Review
3. Implementation FY07	Detail Design & Analysis	• Critical Design Review
4. Implementation	Manufacturing, Integration & Test, and Ground Operations	• Test Readiness Review(s) • Functional Configuration Audit • Physical Configuration Audit • Acceptance Review(s)
5. Implementation	Flight Operations	• Flight Readiness Review
6. Implementation	Retirement & Disposal	• Disposal Review

Business Risk Reduction

In its first year, the SLI plan has been validated and its investments are now focused on enabling current mission requirements, such as servicing the International Space Station and delivering satellites to orbit. The research and development of technologies critical to meeting safety, reliability, and cost goals is well underway.

As part of the SLI philosophy, program management has established processes and procedures to examine the Program's progress from top to bottom. In its first year, the SLI Team applied proven business practices and the latest engineering analysis tools to ensure that investments directly apply to specific mission requirements and the Agency's overall goals of increased safety and reliability, coupled with lower operations costs. An Advanced Engineering Environment has been brought on line to allow remote technical data to be collected and analyzed. Each year, SLI will continue to systematically examine its technology research, bringing content in line with the needs of competing space transportation architecture concepts.

The SLI Team nurtures both human capital and business acumen, as it offers knowledge gained to other Government agencies and private industry. Unlike previous programs where the contractor retained data rights, SLI is buying information and sharing that across the industry platform to enrich the playing field with ripe ideas and disciplined innovation. The Team honors the lessons learned from programs that came before and is being guided by independent review panels and subject matter experts. It has a well-defined and integrated cost accountability system that pays for performance based on clearly stated objectives and schedules. Through its innovative acquisition strategy, the team has created business systems and accountability reviews that ensure the Government gets what it pays for. And SLI makes available what it learns for the common good of other Government agencies and the private sector. For example, NASA recently participated in a joint study with the Department of Defense (DoD) to discover where we might better cooperate and share launch technologies.

Designing a safer, more reliable, and less costly space transportation architecture is not just about hardware. Fundamentally, it is about sound business decisions based on proven business models. Within its first year, SLI has been structured to closely resemble the highly successful Joint Strike Fighter program, which employs lean thinking concepts and acquisition strategies. Although SLI stops short of a prototype flight vehicle, it does include integrated flight demonstrations to validate multiple technologies in real-world environments.

The Program will ultimately succeed because it employs sound business practices and a rigorous systems engineering process, which is the pivotal point where the architectures and technologies converge. Through systems engineering, the Program has the proper insight into the many designs and development areas funded in the first year, and has made critical decisions based on risk reduction, the cost-to-benefit ratio, and relevance to the Agency's overall goal of dramatically improved access to space. Systems engineering defines and integrates key components that enable the credible development and operation of a safe and cost-efficient 2nd Generation RLV and support infrastructure. It provides the tools by which to project how much it will cost to field the new system and make it fully operational next decade.

Technical Risk Reduction

Already, risk reduction activities have yielded valuable information that a year ago could not have been predicted without the fundamental research performed by the SLI Team. Over this past year, architecture concepts were validated and technology development data were analyzed against those credible designs. Each mission requirement was challenged and refined. For example, crew and cargo have been separated to build in safety and cost efficiencies. Autonomous operations, self-diagnosing health monitoring systems, and quicker turnaround processing will allow launch rates to rise and reduce the cost per launch. Fly-back booster propulsion can potentially simplify reusable operations. These are just a few of many meaningful developments.

Program reviews are comprehensive examinations — the IATR at the end of the first contract period gave the insight needed to exercise some options and redefine others. For example, a contract was exercised to develop a propulsion first stage using liquid oxygen and kerosene as a fuel, and that helped drive the decision not to pursue composite tanks, so that work was scaled back in favor of metallic tanks. These examples also underscore that the Program is not rushing to solutions before fully understanding the questions, as these two developments could not have been predicted a year ago without this Government-funded research.

Propulsion Is Key

Experience shows that propulsion is the single largest contributor to unreliability during ascent. Based on assessments of available data, the thermal protection system, main engines, and toxic propellants used in on-orbit maneuvering engines affect 50 percent of the Space Shuttle processing time. Since two of these three cost factors relate to propulsion, and because propulsion takes a long lead time to develop, it holds the key to meeting safety, reliability, and cost goals. For these reasons, propulsion is SLI's top risk reduction area.

In keeping with the Program's lean enterprise theory, propulsion risk reduction will increase each year in correlation with competitive selection of propulsion systems and subsystems, which will ultimately save millions of dollars in overall development cost. SLI has sought to baseline and benchmark itself against a number of similar technology investment programs. Program-wise, we have benchmarked against the Joint Strike Fighter (JSF) and its use of lean thinking to reduce variability in design, development, test, and evaluation (DDT&E). That program has proven that 70 percent of the total leverage to improve life cycle costs (LCC) is an up-front design. Prototype design eliminates and/or reduces failure modes and design uncertainty, and enables requirements control and proper materials selections.

In our propulsion technology research, we used the Space Shuttle Main Engine (SSME) cost of $3.6 billion as a baseline. Engine development improvements since the development of the SSME are estimated to bring down new engine development to about $3.0 billion. Seventy-five percent of SSME development test/fail/fix approach, with the majority of costs being unpredicted— resulting in cascading uncertainty within the cost models. Based on SLI's approach and propulsion investment of about $500 million, are expected to be as low as $1.5 billion.

During the past year, completion of significant milestones such as the Propulsion Systems Requirements Review, ensured that high-priority propulsion systems are on track toward the development of prototype main booster engines, on-orbit non-toxic reaction control thrusters, advanced materials, and environmentally safe propellants. Decisions were made on how to better focus investments to reflect the needs of potential vehicle architectures being designed in parallel. Examples of major propulsion accomplishments include design reviews on main engines and system tests on reaction control thrusters that use non-toxic propellants to create a safer environment for ground operators, lower costs, and increase efficiency with less maintenance and quicker turnaround time between missions. Electromechanical actuators, which offer improved safety and handling features over hydraulics, were tested using the X-33 engine that was already in a test stand.

During FY 2002, the Propulsion effort is continuing technical risk reduction of high-priority technologies, which will include Preliminary Design Reviews (PDR) of major hardware components. PDR will define a clear design process with 10 percent of design drawings complete. These risk reduction activities will allow preparation for the architecture Systems Requirement Review in FY 2003.

Efforts will continue to select viable main engines from several competing designs — engines with greater thrust capabilities, safer operations, and lower maintenance costs than the Space Shuttle Maine Engine. Propulsion projects have been refocused at the beginning of the SLI Program's second year to ensure seamless integration with vehicle requirements. Based on architecture needs outlined in the IATR, contract options have been exercised to include designing an engine that uses easier-to-handle liquid oxygen and purified kerosene (LOX/RP) instead of cryogenic liquid oxygen and hydrogen (LOX/LH2). Using LOX/RP in the first stage of launch will lower the maintenance costs and result in a safer overall architecture capable of drastically reduced turnaround time for the next launch.

Risk reduction activities for propulsion systems will demonstrate improvements over existing technologies such as propellant cross-feed systems and engine health maintenance features. Additional high-priority technology efforts will include jet-powered propulsion for return of the first stage. Jet-powered return of the first stage allows booster flight further down range and to higher velocities. Use of jet-powered propulsion will also reduce the overall weight of the vehicle's second stage. Plans are underway to staff a Crew-Escape and Survival Propulsion Office by the end of FY 2002, which will focus on reducing the risk of safe crew-escape propulsion systems that use advanced solid, liquid, and hybrid propulsion techniques.

Based on successful initial testing of the two competing Reaction Control Systems (RCS), thruster approaches and basic technology for high-concentrate peroxide, propulsion RCS will focus on less toxic peroxide/RP and LOX/ethanol propellants, which will ultimately lower costs of ground operations. Through a partnership with the U.S. Air Force, studies will continue to develop safer peroxide and fuel combination for use in the upper stage propulsion system — basic research is complete and requirements have been identified through successful testing of materials compatibility and detonation. In the upcoming year, additional research will determine the appropriate environmental safety hazard risk reduction. Use of a peroxide fuel combination in the upper stage propulsion system will allow the vehicle to meet very long on-orbit stay requirements, and will be safer for the environment than the toxic storable used in today's systems.

In FY 2003, propulsion elements will begin the advanced phases of sub- and full-scale testing, which will culminate in a Critical Design Review (CDR) of competing engine systems. The CDR will establish finalized design concepts with 90 percent of prototype and existing hardware drawings completed to build the overall engine system. This will ensure that the propulsion systems and architecture concepts are parallel and ready to proceed on budget and on schedule for ground testing beginning in FY 2004 and continuing through FY 2006.

From FY 2004 to FY 2006, significant prototype hardware development and testing of main engines, RCS thrusters, non-toxic propellants, and crew-escape propulsion aimed at formulating a full-scale development decision will take place. Major milestones planned for completion during this period include prototype subsystem testing of the auxiliary propulsion test article, and prototype main engine design, manufacture, test, and integration, resulting in initiation of flight engine design. Having propulsion systems at this point in the research and development cycle will ultimately allow the Agency to go forward with full-scale development of the optimum architecture design.

Learning from the X-33 Project: Tanks

SLI's recent composite tank decision, which was a result of the IATR process, hearkens back to the X-33 flight demonstrator whose business model bypassed the logical progression of technology evolution being followed by the SLI Program. In theory, lightweight composite tanks could translate to huge cost savings. The X-33 experience revealed that the boundaries of such materials were not yet at a point where composites are suitable for certain applications. Building on lessons learned through the X-33 flight demonstrator project, SLI composite tank research validated that the cost-to-benefit ratio of developing that capability may not provide significant advantages over metallic tanks. SLI will continue to monitor the development of composite propellant tanks, and will install such tanks when it feels that the technology is matured enough, safe, reliable, and cost-effective to implement. For the moment, SLI is investigating the unanticipated strides that are being made in aluminum-lithium tank manufacturing.

Based on preliminary architecture assessment results, metallic tanks have been moved from backup to the leader position. As such, the metallic tank effort has been increased and restructured to focus on critical technology needs such as a self-reacting friction stir welding circumferential and complex curvature demonstrations. Preliminary results using composite tanks in cryogenic applications show only minimal weight savings over metallic tanks, but with increased operation and maintenance issues. Therefore, the composite cryotank effort has been moved to a follower position, descoped to a single contractor, and realigned to focus on the operability issues and overall benefit to the architectures.

Since RP has emerged as a primary first stage propulsion option, the need for composite cryotanks is also reduced. Composite tanks are being continued in a follower mode to further study the issues related to risk as well as non-cryo application for RP engines. Again, the IATR was the tool that facilitated gathering and analyzing overall program data, and yielded valuable information on which to base critical decisions.

Thermal Protection System Developments

The vehicle's thermal protection system (TPS) is also part of SLI's extensive airframe research. Significant improvement has been made in hot-powder process manufacturing that helps eliminate flaws in monolithic ceramics, known as Ultra-High Temperature Composites (UHTC). This material, when used as TPS on the sharp leading edges of a Crew Transfer Vehicle, provides increased abort options, thereby improving crew safety. Essentially, UHTC possesses a unique set of material properties including unusually high thermal conductivity, good thermal shock resistance, and modest thermal expansion coefficients that make them particularly well suited for sharp body applications in hypersonic flows. Sharp leading edges (≤1 centimeter) could enable an entire new design space for hypervelocity vehicles with decreased drag, increased cross-range capability, and reduced cost-to-orbit.

NASA Research Announcement 8-30, Cycle II

The IATR process also provided the insight needed to conduct a second round of procurements to fill design and technology gaps. The SLI's first round of awards (NASA Research Announcement (NRA) 8-30, Cycle 1) in May 2001 — valued at $791 million — went to 22 prime contractors and over 150 subcontractors. An additional $94.6 million was awarded in December 2001. In addition to propulsion, Cycle II will focus on crew enhancements, coordinated by the NASA Unique Systems Project, and integrated flight demonstrators to further mitigate the risks associated with developing a 2nd Generation RLV to serve both NASA and commercial needs. The investment is estimated to be about $500 million over the next year.

NASA-Unique Systems

In spite of advances in aerospace technology, human space flight remains a challenging endeavor because of the need to provide flight crews with a safe vehicle. The NASA-Unique Project deals with all aspects of astronaut safety. It includes escape and survival enhancements, a weight-saving inflatable airlock, and the operational features unique to human space flight. This is the Program's top design risk area and the competition is wide open.

The Johnson Space Center is working to understand and simplify upper-stage vehicle designs for servicing the Space Station in the post-Shuttle era. NASA-unique technology projects are also looking at ways to ensure safe extraction of the crew across the flight envelope from pre-launch to landing, akin to similar systems found in jet fighters. Such a system will interact with the crewed vehicle via flight performance health detection sources that can initiate crew escape in the event of an in-flight anomaly.

Flight Demonstration to Supplement Ground Testing

SLI is supported by multiple integrated flight demonstration projects, including the X-37 technology demonstrator. The X-37 demonstrator integrates key SLI advanced technologies for testing in real-world flight environments. The X-37 Project has recently completed a highly successful series of seven drop-tests in the initial atmospheric phase, using a prototype look-alike vehicle called the X-40A. These tests contributed valuable data needed to complete the X-37 design that are now part of the reusable launch vehicle knowledge base.

In technical areas like airframe and thermal protection systems, the X-37 Project could serve as a testbed for support the Space Launch Initiative by demonstrating key technologies needed to develop a 2nd Generation RLV. The next phase of the X-37 Project would conduct a series of five unpowered approach-and-landing flight tests. These tests are a necessary precursor to orbital flights and are currently targeted for 2004. To fulfill that role in supporting the SLI, the X-37 Project will need funding for FY 2003 and beyond and will compete for those additional funds in the NRA 8-30, Cycle II procurement.

Buying Down Risk

As SLI progresses, it will continue to deliver accomplishments that buy down the business and technical risk of full-scale development. In the 2002 to 2003 timeframe, the Systems Requirements Review process will focus the field to a single architecture design from each of three contractors, while further defining the specific technologies that require selected investment to enable a full-scale vehicle to be built and become operational. Independent reviews will be conducted to validate the SLI Team's progress and approach. As SLI moves into this second phase, a Request for Proposals will be released in 2003 to advance the two architectures chosen and specific technologies needed.

In the 2004 to 2005 timeframe, architecture plans will be refined; both technology and business cases will continue to be analyzed; and strides will be made to focus on ground and flight testing of prototype engines, NASA-unique safety features, airframes, and automatic vehicle health monitoring, among others. A Systems Design Review establishes another level of fidelity among the architecture designs and technology readiness levels. Again, independent reviews will be conducted.

In 2006, the two-part Formulation Phase of space transportation development covered by SLI ends and the Implementation Phase begins with a full-scale development decision, based on two competing launch vehicle concepts that have passed the Preliminary Design Review.
In the years leading up to the full-scale development decision, the Space Launch Initiative Cost Credibility Team, formed in February of this year, will review the current state of cost estimation for development, production, and operations in the aerospace industry and formulate recommendations for the life-cycle cost estimates for the next generation of RLVs. The team consists of key experts in this field from NASA, Department of Defense, Aerospace Corporation, Rand Corporation, Institute for Defense Analysis, and the COTRs for each Architecture Definition Office of SLI. The team is collecting data from each industry led architecture development team to serve as the basis for the initial estimates. The preliminary results will be

completed in time to support the SLI Non-advocate Review and will be refined as the key technologies are matured. The estimates for full-scale development will directly depend on the results of the systems requirements review process and the contract awards from the RFP scheduled for late calendar year 2004.

Engine prototypes will be in the test stands, new thermal protection systems will be in development, and flight demonstrators will have integrated and tested multiple technologies. Most importantly, the fundamental question of what kind of vehicle the U.S. launch industry can produce and what its requirements should be will have been resolved. Additionally there will be a great measure of assurance as to how much it will cost to build and operate the new system. Goals such as a $1,000 per pound to orbit cost and a 1-in-10,000 probability of loss of crew are ambitious targets, but they are not the only measures of success. For example, attaining a $2,000 per pound cost and a 1-in-5,000 safety factor would not indicate failure; rather, it would reflect the realities of current analysis of both Government and contractor team members while still achieving great strides over today's Space Shuttle.

Conclusion — We Can Get There from Here

The United States and the world have benefited from scientific discovery and breakthrough exploration that new forms of transportation have historically made possible. In practical terms, space transportation system enables the robust civil exploration of space, while it fosters economic and technological growth across many commercial sectors. The really exciting part of SLI is not just new technologies — it is the promise of a revitalized scientific community and aerospace industry supported by efficient, reliable vehicles from a NASA Program that is deeply committed to cost accountability and delivering value for the money entrusted to its keeping.

The Space Shuttle has served with distinction for over 20 years, but the system requires labor-intensive work and is costly to operate. It also offers an extensive knowledge base upon which to build a firm foundation for a new generation of safer, more reliable, and less expensive space transportation specifically designed for a new generation of missions and markets.

In summary, NASA's Space Launch Initiative is reducing the risks inherent in an advanced research and development program for space transportation while fostering a fair and competitive business environment for industry, and ensuring the efficient use of valuable resources. Through teamwork with its partners in the U.S. aerospace industry, academia, and other Government agencies, SLI is on course to reduce the risk of developing a safer, more reliable, and less expensive space transportation system that will enable NASA to pursue its ultimate goals — to understand and protect our home planet; to explore the universe; and to inspire the next generation of explorers.

Figure 1. SLI Program Schedule

- Mid-Decade: Full-Scale Development Decision
- Early Next Decade: Initial Operational Capability

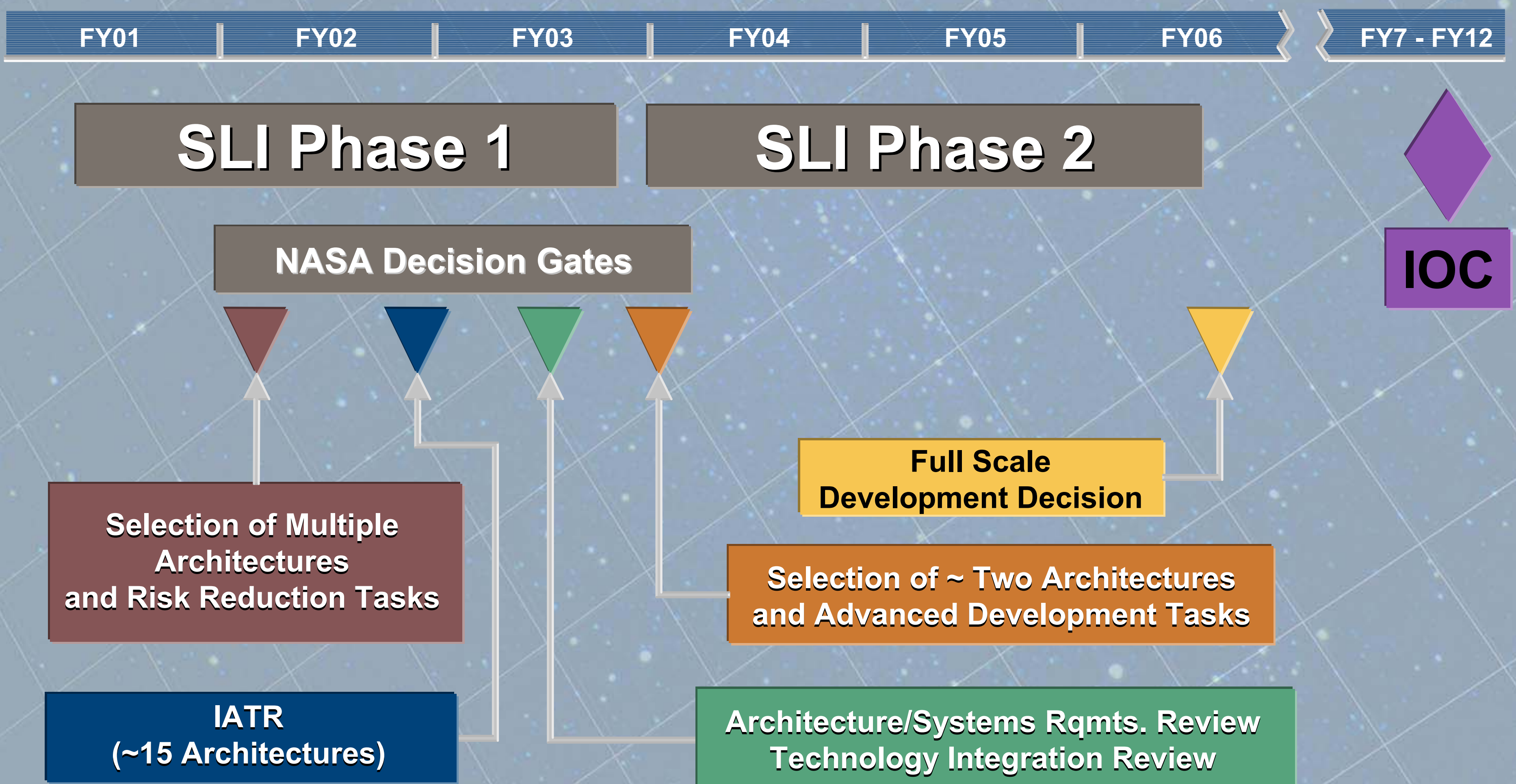

Figure 2. SLI Architecture Field Narrowed, Based on Mission Requirements

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